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FORT LEWIS EXPERIMENT
APPLICATION OF FOOD TECHNOLOGY AND ENGINEERING TO CENTRAL PREPARATION

by

D.B. Rowley, J.M. Tuomy,
and D.E. Westcott,

February 1972

UNITED STATES ARMY
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Natick, Massachusetts 01760

Food Laboratory
FL-157

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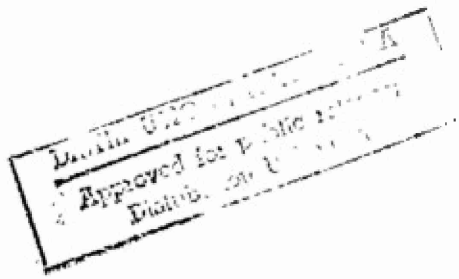
TR--72-46-FL

D. B. Rowley, J. M. Tuomy, and D. E. Westcott, EDITORS



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FOREWORD

In 1969 the DOD Facilities and Equipment Planning Board accomplished an on-site survey of military garrison feeding facilities in the United States. As a result of this survey, this Board created, with DOD and Army approval, a project to study, define, and then implement a new, modern feeding system at Fort Lewis, Washington. As documented in the approval for this project, the objectives were to improve performance and reduce costs. This new system would then serve as a model for all military services.

In 1970 the newly created DOD Research and Development Food Program was implemented at NLABS. Included within this program was an increased emphasis on garrison feeding systems and a new requirement to study military feeding systems from a total systems concept. This new requirement was implemented by the Operations Research and Systems Analysis Office at NLABS, and resulted in a rather unique but logical merger of the R&D systems study effort with the DOD and Army project to study and then build a modern feeding system at Fort Lewis.

It should be noted that due to the extent and complexity of the information and data which have been developed, this report is only one of several technical reports which are being published concerning the overall project. This report covers the food technology efforts conducted in-house at the Natick Laboratories to develop the processing parameters required to assure that the food products served military customers would be both safe and highly acceptable.

The overall study effort was initiated in November, 1970. This study was conducted as Task 03 under Project Number 15662713AJ45, Systems Studies in Military Feeding. The purpose of the overall study activities, of which this report covers only one facet, was to increase customer satisfaction and reduce operating costs, in that order of importance.

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ABSTRACT

This report details the findings of food technology studies directed toward establishment of central food preparation at Ft. Lewis, Washington.

It is concluded that central food preparation has excellent possibilities for improving the feeding system. A basically chill system is recommended for the Ft. Lewis test with the recognition that there are logistic problems to be solved if it is extended to a larger operation. It is shown that changes are necessary in the Armed Service menus and recipes to adapt them to large scale preparation.

OBJECTIVES

The objectives of this study were to determine:

1. — Food technology aspects of a central food preparation facility at Ft. Lewis.
2. — The type of system (hot, chilled, or frozen).
3. — Which foods could be prepared centrally.
4. — Shelf life limitations to insure quality products both organoleptically and microbiologically.
5. — What changes should be made in standard Armed Forces recipes to adapt them to central preparation.

CONCLUSIONS

The Food Laboratory tests indicate that from a technical standpoint central preparation has excellent possibilities of being successful for Armed Service installations where applicable. Food quality can be maintained at a uniformly high level, particularly if proper quality control procedures are instituted. Actual preparation and cooking labor should be reduced. It is estimated that yield increases of better than 20 percent should be possible with proper production scheduling.

From a technical standpoint either a chill or frozen system can be used for a central food preparation facility. Food quality is somewhat better with a chill system, the costs are lower, and the reheating of the foods in the dining halls is less of a problem. For these reasons, Food Laboratory recommends the use of a chill system for the Fort Lewis experiment. A hot system is not recommended.

Probably the biggest problem with a chill system is logistics. Most chilled products have to be consumed within a 4 or 5-day period and some, such as fried chicken, should be consumed within 2 days. With a facility serving a fairly small number of dining halls, the logistics can be worked out, but with a large facility serving possibly over 100 dining halls, the problems can become formidable. In any event, the logistics must be worked out for products such as green salads which cannot be frozen.

A large number of the products in the menu can be prepared centrally. However, with some such as steaks, chops, frozen vegetables, and some roasts, the quality is better when they are prepared for serving in the dining halls, and total labor is less.

Shelf life of the various products is sufficient to insure both microbiological and organoleptic quality when they are properly handled.

The Food Laboratory tests show that Armed Service menus and recipes can be adapted to a central food preparation facility, but they cannot be used as is. Some preparation such as frying steaks or cooking frozen vegetables must still be done in the dining halls. Therefore, the menus must be revised to even out the workloads in both central preparation and the dining halls. Menus should also be revised to offer greater choice and to maximize troop acceptance. Recipes have to be changed to adapt them to large scale preparation and to insure stability when products are held chilled or frozen.

INTRODUCTION

A state-of-the-art survey of advanced high-production feeding systems conducted by US Army Natick Laboratories concluded that the optimal concept for serving 70,000 meals per day to Army customers at Fort Lewis, Washington, was centralized preparation with satellite dining halls. As a result of this work, an in-house task was initiated to determine the optimum processing parameters for centrally preparing food products to be used in both an initial small scale and later pilot plant test at Fort Lewis, Washington.

The utilization of centralized food preparation in an Army garrison feeding system represents a revolutionary departure from the conventional means by which the Army feeds its customers in garrison. It is, therefore, necessary to make a definite distinction between a large kitchen and a central food preparation facility. A kitchen is designed to prepare a complete meal and serve it within a short period after preparation is complete with almost no preparation for future meals. In contrast, a preparation facility is designed to prepare food for use at some future time with the time between preparation and use varying from as little as one day to a month or more. This time factor is the basic reason for the differences between a preparation facility and an oversize kitchen. In a preparation facility the menu for the next meal is no longer the control, and production can be scheduled to optimize personnel skills, available equipment, quality, and production volume of a given item. Planning and control of production are on the basis of unit operations rather than on an item as a complete entity. It is necessary to integrate preparation as processing steps in an overall preparation schedule.

Another departure from conventional Army feeding methods is in recipes and formulations. For example, the common thickening agent in most Army recipes is flour, which under chilled or frozen storage promotes separation of water and fat. At least part of the flour must be replaced with a specially processed starch to prevent this. Large scale preparation, either continuous or batch, involves cooking equipment, schedules, and times differing appreciably from kitchen operations. This affects texture and particularly moisture content which must be corrected for in the formulations. While the basic recipes can be used, changes must be made to most of them. To facilitate central preparation, kitchen recipes must be converted to preparation guides or specifications which take into account large size batches, continuous processing, etc.

The need for sanitation and microbiological controls in any food operation needs no elaboration, but they become even more important in a preparation facility. Bacteria require time and the correct conditions including temperature to multiply. In kitchen operations, time is usually short so that even if the other conditions are optimal the food is normally consumed before the bacteria have much of a chance to multiply. This certainly does not mean that food poisoning outbreaks cannot occur or do not occur in kitchen operations. However, because of the increased time frames in a central preparation operation and the increased number of consumers, the danger

is much greater and strict microbiological controls are essential. As part of these controls preparation, cooking, holding, chilling, and freezing times and temperatures must be carefully planned and controlled. For example, the final cook temperature of a given product must be set high enough to insure microbiological safety. At the same time, it must not be set so high as to materially affect product quality.

Quality control or in its broader aspects, product control, becomes a key factor in successful central preparation operation. In the existing dining hall kitchen operation, quality control is the responsibility of the individual cooks and the mess steward, a practice which can be made to work in a small kitchen with properly trained and motivated personnel. In a preparation operation, operating personnel must still be held responsible for quality, but the skill requirement is much lower because they are aided by full-time personnel whose sole responsibilities are quality control. At the same time, preparation guides must be designed with definite quality check-points in mind.

Before setting up a central food preparation facility, three basic decisions must be made. These are:

1 - Is central preparation feasible and appropriate in the situation under consideration?

2 - Shall the facility be managed as a kitchen or as a food preparation facility?

3 - Should the basic system be hot, chilled, or frozen?

The first decision is not a food technology decision per se, but must be made and firmly implemented if central preparation is to be successful. The second decision has been discussed above, but it must be emphasized that proper operation, cost savings, and standardized good food quality hinge upon the type of operation. The third decision will affect food quality and require menu and recipe adjustments, but primarily will dictate logistics and equipment. Any system used will be a combination of more than one method, but one must be selected as the primary method.

FORT LEWIS EXPERIMENT — PRELIMINARY CONSIDERATIONS

A review of the three available systems — hot, chilled, or frozen — resulted in a tentative decision that if technologically feasible, a chill system (either standard or one similar to the Swedish NACKA system) would be desirable at Ft. Lewis. A hot system was rejected on the basis of the logistical difficulties in delivering hot food to a large number of dining halls without losing nutritional value and troop acceptance. A frozen system could match a chill system for quality if properly handled, but would pose equipment and reconstitution problems. A chill system would be advantageous from the standpoint of food quality, reduced engineering costs, and system discipline. In order to make a sound decision on which type of system to use in the Ft. Lewis experiment, the Food Laboratory conducted pilot plant studies on the various foods which would be prepared at Ft. Lewis during the experiment concentrating on chilled and frozen systems.

Very little is available in the published literature on the quality, stability, and microbiological aspects of foods held in the chilled state and almost nothing is available on these factors in either chilled or frozen states with products made according to the Armed Services recipes and with ingredients in the Armed Services supply system. Due to compressed time frames and the need to try out recipes revised for large scale production not all products could be physically tested, nor were the tests as detailed as might be desired.

Recommendations were required from the Food Laboratory on all foods to be used in the Ft. Lewis experiment on the following points:

1. Should the product be prepared centrally or in the dining hall?
2. If prepared centrally, should the product be carried in the chilled system or must it be frozen?
3. What should be the shelf life limitation to insure a quality product both organoleptically and microbiologically?
4. What changes should be made in recipes and preparation instructions to adapt them to volume production and the chill system?

In addition to these points, it became necessary for Food Laboratory to take the lead in changing the menus in the 42-day menu cycle in order to increase menu choice, delete low preference items and to even out the work-load on central preparation and the dining sites. Three sets of forms were prepared for the whole 42-day cycle to include (1) daily menus, (2) breakdown of each menu listing each item, referenced recipe, and what had to be done to it centrally and in the dining hall, and (3) production guide for each item where it differed from the standard recipe.

The basic philosophy behind recommendations for central or dining hall preparation was to move as much work as possible to central preparation saving manpower in the dining hall and supplying uniformly high quality products to the dining tables. Many of the decisions were based upon the state of the raw product in the supply system. For example, frozen vegetables require only heating to be ready for serving and central preparation would not improve quality or save labor. Breaded fish and shrimp can be cooked in a minute or two in deep fat and central cooking would increase labor and decrease quality. Grilled products such as steaks or chops require little preparation and are of much better quality when prepared in the dining hall. Very little work can be saved in the dining hall with a roast unless it is cooked and sliced centrally to be heated on-site with gravy. However, this would result in significant quality loss particularly if rare roast beef is desired. Table I lists the various product classes and preparation required at each location as determined to be the most suitable for the Ft. Lewis experiment.

PRODUCT TESTING

The two commodity divisions of the Food Laboratory (Plant Products Division and Animal Products Division) are the product oriented divisions and contain most of the Food Technology expertise in the Food Laboratory. They were therefore assigned the responsibility of product testing and revision for the Ft. Lewis experiment with help from the other divisions as required. The work followed division lines and was broadly divided into meat and entree items, fruits and vegetables, and bakery. A general test plan was set up in which products in the 42 day menu cycle were evaluated and adjustments made in the recipes to adapt them to quantity preparation and a chill or frozen system. The products were then made in approximately 100-lb batches and tested over a 10-day period by a technological taste panel to determine the effects of holding on quality. Insufficient time was available to test every one of the more than 230 basic items plus variations in the 42-day cycle but every class or type of food was represented in the tests. In addition, some products were sufficiently different so that they did not fit a standard test plan. In this case special tests were used.

A 10 member technological sensory panel using a 9-point quality attribute rating scale (1 - extremely poor; 9 - excellent) was the primary tool used by the commodity divisions to determine quality changes brought about by recipe changes and holding periods. The panel members were chosen for their knowledge of the test product without regard to sensitivity rather than chosen randomly so that extrapolating consumer acceptance is not valid. Many of the products were submitted to the Natick Laboratories Consumer Acceptance Taste Panel to obtain acceptance data as an indication of how well the products would be accepted by consumers at Ft. Lewis. The panel results were not analyzed statistically since the raw data provided enough information for the purpose.

Bakery Items

The concept of central preparation of bakery products is obviously not new to military feeding systems. Central pastry shops are considered as "state-of-the-art", and are in use at several installations. TM10-411 provides some background pertinent to central pastry kitchens and it is recommended that this concept be instituted at Ft. Lewis at the time that central preparation is scaled up to support the entire installation.

Bakery products in general have a shelf-life which is dependent upon their composition and the effectiveness of the packaging system employed. To minimize staling caused by

chemical and physical changes in structure of baked goods the use of emulsifiers and dough conditioners is recommended. The new bakery mixes in the supply system have been formulated with these additives and should be used to the maximum extent. This will also give the most reliability and efficiency in the production of quality products. Where items must be produced from "scratch" the use of sodium steroyl-2 lactylate (EMPLEX) at a level of 1/2 ounce per 100 ounces of flour (0.5%) is recommended.

Drying is prevented by proper packaging after the product has been cooled. Packaging without sufficient cooling results in condensation on the inside of the package which fosters mold growth and causes softening and stickiness. Cooling may be accelerated by placing baked products on racks and using fans to increase air circulation. Those products that can be handled appropriately (e.g., rolls, cookies) should be placed in polyethylene bags. Those that must be left in the pan such as crisps or cake puddings should be inserted into a "poly" bag or covered with aluminum foil. Frosted cakes and pies need no package but must be protected from contamination with dust, dirt, etc.

Selected products representative of various types were evaluated in the laboratory for acceptability during storage. Results are summarized in Table 2. Only crisps, puddings and non fruit pies require refrigeration; all other items may be stored at room temperature. All products were found to maintain a high acceptance level for at least 48 hours after production. The items were produced in accordance with the standard Armed Forces Recipe Service; no modifications were found to be necessary except for the addition of the emulsifier, Emplex.

Gelatin Salads and Desserts; Marinated Salads

Gelatin products are refrigerated after preparation to aid in the gelling process and to lower the temperature to the normal serving level. They are ideally suited to a central preparation system since they have good shelf-life as evidenced by their availability on the retail market.

Marinated salads such as cole slaw, three-bean, cucumber and onion, etc. require a period of time to equilibrate and achieve a well-blended flavor. These products also are available on the consumer market since they have an adequate shelf-life due to their high acidity (vinegar).

It was not felt necessary to conduct laboratory studies on these products for commercial experience indicates that they would be suitable for the proposed Ft. Lewis system.

Meat and Entree Items

The meat and entree items were made in 100-lb. batches. Changes in recipes were designed primarily to improve the holding qualities by substitution of starch for some of the flour to

prevent breakdown of the gravy emulsions, and to adjust the water content. In some cases changes were made to improve handling and processing conditions in large batches. Products were proportioned in 1/2 steam table pans (stainless steel), chilled and covered with aluminum foil for storage. Technological panels evaluated the products held chilled at 40°F and frozen at 0°F for 0, 1, 2, 3, 7 and 10 days. The 7 and 10 day periods were used for the 40° product only to complete trend graphs with no expectations of the product quality being satisfactory. The panels evaluated the products for color, odor, flavor, texture and appearance on a 9-point quality scale after heating in a convection oven. Table 3 shows the results for flavor. Scores for the other factors either followed the flavor scores or remained higher except where noted.

Salads (green or "tossed" type)

Previous laboratory work had shown that fresh, cut vegetables prepared under suitable conditions could be held in good condition at 40°F. for periods exceeding one week. The following procedure was found to give good results:

a) Discard wrapper leaves of lettuce heads and trim vegetables as required.

b) Wash salad vegetables thoroughly.

c) Cut, dice, tear, shred as appropriate.

d) Dip into antioxidant solution 2-4 minutes. (Solution is prepared by adding 10 grams of Antioxidant Compound (MIL-A-35043) per gallon of water. The material is a mixture of sodium bisulfite, citric acid and ascorbic acid which retards bacterial growth, and oxidative changes in the fresh plant tissue.)

e) Drain

f) Centrifuge, i.e.. spin dry to remove excess surface moisture which would accelerate decomposition.

g) Package in polyethylene bags.

h) Refrigerate (40°F. or below).

It was found feasible to combine the salad vegetables in their proper proportions as they are prepared. However, tomatoes should not be included since they do not withstand the handling required. Tomatoes can be cut and separately packaged to be added to the salad at the time of serving in the dining hall.

Care must also be exercised to minimize exposure to temperatures above 40°F., and to rough handling that will bruise or crush more delicate vegetable tissues such as lettuce. It was found that much more acceptable salads resulted if dressings were added at time of serving from a variety of dressings which could easily be provided at the dining halls.

Salad Dressings, Sauces, Gravies and Toppings

A review was made of products in these categories that appeared on the 42-day Master Menu. It was evident from a technological point of view that except for gravies, there would be no problem in the central preparation of these items. They all can be prepared, chilled, distributed and served with no anticipated loss of quality within a normal cycle of time, i.e., a shelf-life of at least four days.

In the case of gravies, it was known that physical breakdown occurs when wheat flour is used as a thickening agent and the products are temperature cycled-chilled (or frozen) and reheated. This also was obvious from previous work with precooked entree items. A commercial pregelatinized waxy maize starch (COLFLO-67) has been found to be a suitable stabilizer when used as a partial replacement for wheat flour in gravy recipes. Production guides for all gravies, whether used as a component of an entree item or furnished separately for heating and serving directly, were developed and tested.

Sandwiches (Frozen)

There was a requirement to design sandwiches that would be frozen and later thawed to 40°F for serving. The main reasons for wanting a sandwich capable of freezing was so they could be manufactured on an efficient, large-scale basis and to have a suitable inventory on hand for use at various dining halls on short notice.

The types of sandwiches tested were tuna-salad, ham, ham and cheese, chicken, turkey, and roast beef. There was a problem with freezing a tuna-salad mixture due to mayonnaise breakdown, but by including minimal amounts of mayonnaise and sweet relish in the tuna a suitable salad spread was attained. There was no great problem with ham, cheese and roast beef, except for drying out and soaking of moisture into the bread. To overcome this problem margarine was softened and brushed onto the inner sides of the bread. The margarine served as a moisture barrier between the bread and the meat constituents and also added some flavor to the sandwich. To further eliminate dryness a fine textured (continuous mix) bread and adequate packaging were used.

The sandwiches were cut diagonally and arranged on two different types of plastic trays. One tray contained three half-sandwiches of the same variety and the other, four different half-sandwiches. The trays were garnished with sweet pickle, ripe and green olives. The entire tray was overwrapped with a Saran film cover to give a suitable package for storage and display. Table 4 shows the panel ratings for sandwiches after storage.

Soups

Preparation of soup is highly compatible with the central preparation-satellite dining hall feeding system. Soup concentrates, similar to the commercially canned products, provide the advantage of eliminating the need to distribute unnecessary water. For experimental purposes and to standardize on a simplified system, representative types of soup were evaluated using a standard two-fold concentration. Preparation for serving involves merely the addition of an equal volume of water and heating to 165°F. prior to serving.

The development of soup concentrates required changes to recipes in the Armed Forces Recipe Service involving the following:

(1) Adjustments in water levels.
(2) Variations in order of assembling ingredients because of water level adjustments.
(3) Variations in method of make up because of water level adjustments.
(4) Use of Soup and Gravy Base in place of beef or ham stock where possible.
(5) Use of dehydrates in place of fresh vegetables in certain instances.
(6) Adjustments in seasoning levels.

Acceptance panels and technological panels were conducted on these products over a period of 1 to 13 days (with storage to 40°F.). The results of these panels are shown in Table 5.

A search was made to determine whether there was any food service equipment available which could be used for transporting soups and gravies without spillage. Lincoln Food Service Systems manufactures and markets an 8-quart stainless steel spill-proof container Model HGP-8 for transporting soups and other liquid type foods and this was recommended for use at Fort Lewis.

Specialty Cafe Products

Recommendations were developed for nine "nationality type" foods for use in the Specialty Cafe being planned for Ft. Lewis. Production guides were developed in the meat and entree item category for spaghetti, lasagna, and chili con carne. It was recommended that ravioli and enchiladas be procured as frozen prepared items since their preparation involves excessive labor and special skill. Production guides for refried beans, Spanish rice, five varieties of pizza, and components for tacos were developed with the standard recipes providing the basic guidelines. Pizza was evaluated by panel testing after both refrigerated and frozen storage. Results are shown in Table 6.

Vegetables (other than potatoes)

Most vegetables that are served plain (except for butter) are supplied either frozen or canned. It was evident that no labor savings could be gained by precooking these items centrally. In fact, quality loss would result due to the double heating process — central and in the dining hall. However, for those products requiring formulating or for those received raw it was logical to use central preparation. Raw vegetables to be prepared and cooked centrally included onions, cabbage, and carrots. Experimentation showed no significant loss in quality for these products when reheated after storage at 40°F. for up to two days.

Panel tests showed significantly improved ratings for French fried onion rings that were fried just prior to serving rather than prefried centrally. In view of the excessive labor and difficulty in preparing a quality item, it was decided to use commercial frozen onion rings (not pre-fried) which were found to be highly acceptable.

Vegetables (Potato Products)

Potatoes are a principle component of a military menu, normally being served in some form at least twice a day. Therefore, considerable effort was given to their adaptation to a central preparation system. The following summarizes the findings:

a. In-season potatoes should be used as much as possible to give the best product. Stored potatoes tended to develop gray or black spots after cooking and holding.

b. Best results were obtained when potatoes were only blanched initially and the cooking was completed just prior to serving. This was true whether the item was to be baked, fried, boiled, or grilled.

c. Preliminary processing steps are the same for all products:

(1) Washing
(2) Peeling
(3) Cutting
(4) Antioxidant treatment (sulfur dioxide solution to prevent discoloration)
(5) Blanching — time depends upon piece size but should not be so long as to cook the potato, but merely sufficient to inactivate the enzymes and remove the raw crispiness.

d. Due to the large usage planned and the uniform quality available, it was recommended that commercial frozen (blanched) French fries be used at Ft. Lewis.

e. Freezing of the other potato items should be avoided due to the adverse effects on texture (mushiness).

Table 7 gives the summarized results of panel tests on the various potato products which were selected for laboratory testing as being representative of the several types used in the menu.

MICROBIOLOGICAL EXAMINATION OF TEST ITEMS

Menu items which were representative of foods to be utilized in the central feeding system at Fort Lewis, Washington, and prepared at Natick Laboratories were tested microbiologically during refrigerated storage at 40°F. for up to 9 days. Sixty-two items were tested for mesophilic and psychrophilic microorganisms immediately after cooking or partial baking (0 time) and at various intervals during a 9-day storage period. The results are presented in Tables 8, 9, 10 and 11 according to food category. Since the mesophilic and psychrophilic counts did not differ substantially, the following discussion pertains only to the mesophilic counts.

Tables 8 and 9 show that cooked meat and vegetable items had very low initial counts (0 time) and the counts were either retarded or reduced during refrigerated storage at 40°F., with the exception of roast beef, corned beef and O'Brien potatoes. The increase in counts in the two meat items to 15,000 and 16,000 microorganisms per gram respectively (Table 8) was attributed to an improperly cleaned meat slicer which was used to slice the meat prior to the analysis. Raw vealburgers had very high counts and vealburger stored at 40°F for six days had a tenfold higher count than frozen vealburger. Some partially cooked or baked vegetable items (Table 9) had relatively high initial counts which increased during refrigerated storage to more than a million organisms per gram (partially baked lyonnaise potatoes, for example).

Microbial counts of soups and chowders were very low initially and did not increase during refrigerated storage (Table 10). One exception was cream of potato soup which increased from 200 microorganisms per gram initially to 180,000 per gram after 7 days storage. It is also shown in Table 10 that salads had high counts with the exception of cucumber salad with vinegar. The effect of vinegar in inhibiting and reducing microbial growth was apparent and accounted for the low count (2500/g) after 8 days storage. However, the count in cucumber salad without vinegar exceeded 1 million microorganisms per gram after 3 days storage and increased to 35 million per gram after 8 days. Counts in Waldorf salad also decreased during refrigerated storage, probably due to the effect of acids. Although carrot salad showed no increase in counts after 4 days storage, the count increased tenfold to 3.6 million microorganisms per gram after storage for 9 days.

Table 11 shows that pastries contained very low numbers of microorganisms which did not increase during refrigerated storage for 6 days. The relatively high initial count of 23,000 per gram for chocolate pie was due to the addition of canned whip cream which had a count greater than one million microorganisms per gram. Subsequent counts on chocolate pie without whip cream were very low.

Sandwiches were prepared and stored frozen for 7 days at -10°F. They were then thawed at 40°F. for two days and examined microbiologically for aerobic plate counts, fecal indicators and coagulase positive staphylococci. Table 12 shows that counts were very low for sandwiches with the exception of ham and ham and cheese with margarine which, in addition to having high aerobic counts, contained coliforms. Except for tuna-fish, sandwiches with margarine had higher counts. Although one roast beef sandwich with margarine had low counts it contained coagulase positive staphylococci. Since disposable plastic gloves were worn to prepare the sandwiches the source of contamination would appear to be the margarine.

Generally, with one or two exceptions, cooked or baked menu items withstood refrigerated storage for up to 9 days without spoilage or excessive microbial growth. However, great caution must be exercised when storing cooked, partially cooked and uncooked foods for several days. Failure to destroy pathogens and spoilage organisms or post-process introduction of these organisms will result in growth during prolonged refrigerated storage. This is particularly so for partially cooked or baked foods and salads without dressing. During storage of chilled prepared foods refrigerators must be operated properly and closely monitored to ensure against a rise in temperature allowing growth of microorganisms.

Cooked foods showing high plate counts after refrigerated storage (e.g., 180,000 per gram of cream of potato soup after 7 days - Table 10) are not necessarily considered hazardous because of the actual count. However, total plate counts greater than 100,000 would be suggestive of improper handling (e.g., insufficient cooking, prolonged holding of cooked food at ambient temperature, inadequate refrigeration) and potential hazard from microorganisms causing food-borne illnesses (intoxications and infections). One must realize that some bacteria (S. aureus, S. typhimurium) of public health significance may multiply to dangerous levels without noticeably altering the appearance, odor or flavor of prepared foods.

MICROBIOLOGICAL CONTROLS FOR FT. LEWIS

Central preparation of food necessitates modification of the time-temperature requirements of Chapter 5, AR 40-5. This is particularly true of the chill system prepared for Ft. Lewis where the foods can be held refrigerated 96 hours between preparation and consumption. In order to properly safeguard microbiological aspects of the food during the Ft. Lewis experiment, the following temperature constraints and conditions were recommended realizing that modifications may be required as the experiment progressed.

1. The internal temperature of food items cooked at the Central Food Preparation Facility (CFPF) is to be not less than 165°F.

2. Food items must be chilled to 45°F within 2 hours and subsequently stored at not more than 40°F. The temperature during transportation should not exceed 45°F for more than 2 hours, or 50°F for more than one hour. Raw vegetaoles will be stored at 40°F or below (without freezing).

3. Food items cooked and chilled at the CFPF will be stored at the satellite kitchens at 40°F or below if the storage period is to exceed 8 hours, or 45°F if it is to be used within 8 hours.

4. An item prepared by the CFPF cannot be stored in the chilled system for more than 96 hours. This expiration date will be indicated on the package label. The label shall not be altered in any manner. Any changes (see item 5) should be indicated with an additional label. Prefried bacon can be held 15 days frozen or 5 days chilled. It may be held 24 hours after heating if properly refrigerated (40°F or below) and then used for garnish. Thawed egg mix shall be used immediately or discarded.

5. Chilled foods to be frozen by CFPF shall not be held in the chill system more than one calendar day before freezing. This additional process will occur only with the express permission and under the direct supervision of authorized supervisory personnal designated in 10 below.

6. The internal temperature attained during reheating of chilled and frozen items in the satellite kitchen for serving shall be 165°F or above.

7. During serving the internal temperature of reheated items (6 above) shall be not less than 150°F.

8. A chilled or frozen food that has been reheated for serving at a satellite kitchen can not be rechilled for use without the express permission of supervisory personnel indicated in 10 below.

9. All frozen food items must be thawed either in a refrigerator below 45°F or by cooking.

10. The supervisory personnel authorized to modify the above constraints where indicated are senior food technologists, microbiologists and quality control personnel. Quality control personnel must be notified whenever modifications are being considered. This process requires that all responsible personnel must check the cooking and chilling procedures and temperatures. Malfunctioning equipment must be repaired immediately. All legitimate requests for a proper dial thermometer will be honored.

Microbiological controls are shown as flow charts in Figures 1, 2,

NLABS DINING HALL TEST

As a part of the Food Laboratory tests of products in a chill system, seven products were made in the pilot plant and supplied chilled to the Natick Laboratories Headquarters Company Dining Hall to gain some idea of how the system would work technologically. The Dining Hall feeds approximately 80 persons so lots were made in 100-portion size. No attempt was made to obtain ratings or comments from the persons eating the food. The products tested were country style chicken, tossed salad, O'Brien potatoes, lasagna, chiffonade dressing, lemon cake pudding and peach crisp. No technological difficulties were encountered. Comments from the mess steward and cooks were very favorable both as to the quality of the products, the ease of handling, and the saving of work. Informal comments from various persons eating the products were very favorable.

NACKA SYSTEM

Some interest was expressed in testing the NACKA system, a Swedish chill system in which the products are sealed in plastic bags under vacuum and pasteurized. It is claimed that chilled products will maintain their quality for as long as 30 days with this system. Therefore, some of the products were tested using an approximation of the NACKA system, but only holding the products 10 days as with the other systems. It was found that the quality generally followed that of the regular chill system. It was decided that the NACKA system was not applicable to the Ft. Lewis experiment as designed since additional equipment would be required and the system is really applicable only to casserole and similar items. Therefore, test work was discontinued for this study.

CHILL SYSTEM FOR FT. LEWIS

The chill system to be used in the Ft. Lewis experiment requires a means for rapidly chilling products, primarily in 5-pound pans, from 175°F. to 40-50°F. A survey was made which showed that commercial blast chillers or freezers were not readily available and time was not available in which to design and build special chillers. Therefore, it was decided to convert a standard Army 70 cu. ft. freezer box (MIL-R-43024C) without refrigeration unit to use with liquid nitrogen. Ultimately, two such boxes were converted.

Design requirements based on the experimental plan included the following:

1. Chill 1600 pounds of product in 8 hours.
2. Reduce temperature from 175° to 45°F. maximum without surface freezing.
3. Provide a product handling system.
4. Provide operation and maintenance as simple and trouble-free as possible.
5. Complete design, construction, testing, and delivery of unit(s) to Ft. Lewis, meeting test schedule.

A system for using liquid nitrogen was installed in the box consisting of 3/8 inch copper tubing perforated so as to maintain uniform pressure and to spray liquid nitrogen toward the food. To provide for faster and more uniform cooling, a 7000 CFM fan was installed. A temperature control system was used which sensed the box temperature and activated the flow control valves. Gas pressure in the nitrogen storage tank supplied the energy to operate the valves. Bakery carts were used to hold the product. The carts have 6 shelves which would hold 8 pans of food on the 5 lower shelves and 7 pans on the top shelf for a total of 47 pans containing approximately 235 pounds of product. A ramp was constructed to facilitate moving the carts in and out of the box.

Initial tests showed wide temperature variations with some freezing occurring. Final product internal temperature varied from 10 to 86°F after 60 minutes. This would not be acceptable. Therefore, the piping was changed and baffles installed so that the liquid nitrogen did not impinge directly onto the product. In addition, the fan was wired to reverse direction periodically. Several tests of the box loaded with product showed that design criteria could be met with these changes and some alteration to the temperature programming. A cycle time of 120 minutes was established for the chill operation. The box can be used for rapid freezing as well as chilling.

The chill box has the advantages of low capital cost, simple and trouble-free operation, and its operation is not affected by the presence of water vapor. For a permanent installation, mechanical refrigeration would be much less costly in the long run.

OPERATION OF CENTRAL FOOD PREPARATION

In setting up and operating a central food preparation facility in the Army, there are several areas which are particularly sensitive to problems. They are generated primarily because a new system is being imposed upon an old system. In general, these areas are management, personnel, logistics, and equipment.

The Army does not train or employ food preparation managers. Food service personnel receive training in operating and servicing dining halls, but know very little about managing a preparation facility. Thus, their inclination would be to run the central facility as they would a dining hall. Since the central facility must be run as a preparation facility to obtain cost and operating efficiency as well as good quality, management must be trained and oriented in the proper techniques. One of the most important skills to be mastered is proper scheduling.

Proper training of both central preparation and dining hall personnel is extremely important. One of the big advantages of central preparation is the possibility of maintaining consistently good food quality. However, this quality cannot be obtained or maintained without proper training of the personnel. Food quality can be ruined anywhere along the line, — raw materials, central preparation, transportation and holding, dining hall preparation, or on the serving line — with no possibility of recovery. And quality depends in the last analysis upon people. Training considered proper for a cook or a chef is only in part applicable to a central preparation system and personnel in the current system are not necessarily qualified for the new system without further intensive training.

The Army logistics system for procuring and delivering raw materials for food preparation is of long standing and operates with excellent efficiency. Army officers, civilians, and NCO's who run the system have, in effect, been "brought up" under it, understand it, and believe in it. To impose a new system upon the current one is almost certain to cause strain and problems both at the interfaces of the two systems and in the new system itself where it is operated by personnel familiar with only the old system. If the central preparation is to operate as a preparation facility, the materials are not necessarily delivered in the strict sequence of the 42-day menu cycle, but rather are delivered as required by production schedules. Thus, not only personnel directly assigned to the central preparation facility must be trained in the new system, but also personnel of the various supply points must not allow red tape and previous methods to hamstring the new system. Furthermore, many items are not processed in central preparation so that the system either has to provide for direct delivery to the dining halls from supply points or for central preparation to act as ration breakdown.

The logistics from central preparation to dining table are much more visible and are an actual part of the new system so that proper operation becomes a matter of good training.

While central preparation is a new concept for Army installations, the idea of producing foods in large quantities is not. Machines and equipment are available for continuous production, automated operations, etc., which would save on labor and time. However, the Ft. Lewis experiment was set up to prove out the concept of central preparation in an Army environment with production extended to cover all foods in the menu susceptible to central preparation. This could be done with a facility that would produce the uniformly good quality food which could be expected from a well-run, modern facility in quantities sufficient to supply the test dining halls. Such a facility could be "jury rigged" using existing buildings and equipment padded out with a minimum of special equipment. The efficiency of such a set-up will be very poor since building restrictions will prevent proper layouts and the lack of modern, high-volume equipment will necessitate excessive hand labor. However, there is no reason that such a facility cannot produce excellent quality food even though the efficiency will be poor. Thus, the actual facility will not inhibit proving out the concept of central preparation. Preliminary reports from Ft. Lewis indicate that, while the central prepartion facility set up there for the test is not efficient, the idea of central preparation is very successful from the standpoint of troop acceptance and other factors. Efficiency will come with a modern design facility.

TABLE 1

Recommended Product Preparation Breakdown
Central Preparation — Chill System 1/ 2/

Product	Central Preparation	Dining Hall
Applesauce		Open can, serve
Asparagus, buttered		Cook, serve
Bacon, grilled or baked	Prefry, chill or freeze	Heat, serve
Beans, baked	Prepare, chill	Heat, serve
Beans, green, buttered		Cook, serve
Beans, lima, buttered		Cook, serve
Beans, wax, buttered		Cook, serve
Beef, barbecued (on buns)	Prepare, cook, chill	Heat, serve
Beef, Cheeseburger	Slice cheese	Prepare, cook, serve
Beef, corned	Cook, chill	Heat, slice, serve
Beef, cubes, barbecued	Prepare, cook, chill	Heat, serve
Beef, ground, barbecued	Prepare, cook, chill	Heat, serve
Beef, ground, creamed	Prepare, cook, chill	Heat, serve
Beef, hamburger		Cook, serve
Beef, patties, baked, Spanish	Prepare, cook, chill	Heat, serve
Beef, pot pie	Prepare, cook, chill	Heat, serve
Beef, pot roast	Prepare, cook, slice, chill	Heat, serve
Beef, roast		Prepare, cook, serve
Beef, steak, grilled		Cook, serve
Beef, steak, pepper	Prepare, cook, chill	Heat, serve
Beef, steak, salisbury	Prepare, cook, chill	Heat, serve
Beef, steak, swiss	Prepare, cook, chill	Heat, serve
Beef stew	Prepare, cook, chill	Heat, serve
Beets, harvard	Prepare, chill	Heat, serve
Biscuits, baking powder	Prepare, bake	Heat, serve
Biscuits, cheese	Prepare, bake	Heat, serve
Bread, assorted		Serve
Bread, corn	Prepare, bake	Cut, serve
Broccoli, buttered		Cook, serve
Broccoli, polonaise	Prepare, cook, chill	Heat, serve
Brownies	Prepare, bake	Serve
Brussel sprouts, buttered		Cook, serve
Buns, assorted	Prepare, bake	Serve
Buns, hamburger		Serve
Butter		Serve

Product	Central Preparation	Dining Hall
Cabbage, buttered	Prepare cabbage	Cook, serve
Cakes	Prepare, bake	Cut, serve
Carrots, glazed	Prepare, chill	Conk, serve
Carrots, lyonnaise	Prepare carrots	Cook, serve
Carrots, normandie	Prepare carrots	Cook, serve
Carrot sticks	Prepare	Serve
Catsup		Serve
Cauliflower, buttered		Prepare, cook, serve
Celery sticks	Prepare	Serve
Cheese, grated	Prepare	Serve
Chicken, barbecued	Prepare, cook, chill	Heat, serve
Chicken, country style	Prepare, cook, chill	Heat, serve
Chicken, fried	Prepare, cook, chill	Heat, serve
Chicken, oven fried	Prepare, cook, chill	Heat, serve
Chicken, pot pie	Prepare, cook, chill	Heat, serve
Chili con carne	Prepare, cook, chill	Heat, serve
Chop suey, pork	Prepare, cook, chill	Heat, serve
Clam chowder	Prepare, cook, chill	Dilute, heat, serve
Coffee		Prepare, serve
Cole slaw	Prepare cabbage, dressing	Combine, serve
Cookies	Prepare, bake	Serve
Corn, cream style		Open can, heat, serve
Corn, O'Brien	Prepare, chill, pre-fry bacon	Combine, heat, serve
Corn, on cob	Shuck corn, chill	Cook, serve
Corn, sauteed	Prepare, cook, chill	Heat, serve
Corn, southern style		Prepare, cook, serve
Corn, whole grain		Cook, serve
Crackers		Serve
Cranberry sauce		Open can, serve
Crisps, apple, cherry or peach	Prepare, bake	Cut, serve
Doughnuts	Prepare, cook	Serve
Dressing, bread	Prepare, cook, chill	Heat, serve
Dressing, salad	Prepare, chill	Serve
Dressing, sausage	Prepare, cook, chill	Heat, serve
Egg omelet	Prepare mix, freeze	Thaw, cook, serve
Eggs, hard cooked	Prepare, chill	Serve
Eggs, scrambled	Prepare mix, freeze	Thaw, cook, serve
Eggs, to order		Cook, serve
Farina, hot		Cook, serve
Fish, baked		Prepare, cook, serve
Fish, french fried		Cook, serve
Fishwich		Cook fish, combine, serve
Frankfurters, barbecued	Prepare, cook, chill	Heat, serve
Frankfurters, simmered		Cook, serve

Product	Central Preparation	Dining Hall
Fruit, canned		Open can, serve
Fruit cocktail		Open can, serve
Fruit, fresh		Serve
Gelatin desserts	Prepare	Serve
Gingerbread	Prepare, bake	Serve
Gravies	Prepare, cook, chill	Heat, serve
Greens, southern style		Cook, serve
Grits, hominy		Cook, serve
Ham, baked		Cook, slice, serve
Ham, fresh, roast		Cook, slice, serve
Ham, grilled or fried	Slice ham	Cook, serve
Ham steaks, baked	Slice ham	Cook, serve
Hash, beef	Prepare, cook, chill	Heat, serve
Hash, corned beef	Prepare, cook, chill	Heat, serve
Hermits	Prepare, bake	Serve
Ice cream		Serve
Juices		Open can, serve
Lasagna	Prepare, cook, chill	Heat, cut, serve
Lemonade		Prepare, serve
Lemon wedges		Prepare, serve
Limeade		Serve
Macaroni and cheese	Prepare, cook, chill	Heat, serve
Meatballs, swedish	Prepare, cook, chill	Heat, serve
Meat loaf	Prepare, cook, chill	Heat, slice, serve
Meat platter, cold	Slice meats	Serve
Milk		Serve
Muffins	Prepare, bake	Serve
Mushrooms, sauteed		Open can, cook,serve
Mustard		Serve
Noodles, buttered		Cook, serve
Noodles, chow mein		Open can, serve
Oatmeal, hot		Prepare, cook, serve
Olives, green or ripe		Serve
Onion rings, french fried		Cook, serve
Onions, baked with tomatoes	Prepare, cook, chill	Heat, serve
Onions, spanish	Prepare, cook, chill	Heat, serve
Pancakes		Prepare, cook, serve
Peas and carrots, buttered		Cook, serve
Peas and mushrooms, buttered		Cook, serve
Peas, blackeye		Cook, serve
Peas, buttered		Cook, serve
Pickles		Serve
Pies	Prepare, bake	Cut, serve
Pizza,	Prepare, cook, freeze	Heat, cut, serve
Pork, baked, stuffed	Prepare, cook, chill	Heat, serve
Pork loin, barbecued	Prepare, cook, chill	Heat, serve
Pork roast		Cook, slice, serve
Pork sausage, baked		Cook, serve

Product	Central Preparation	Dining Hall
Pork slices, baked	Prepare, cook, chill	Heat, serve
Pork spareribs	Prepare, cook, chill	Heat, serve
Pork spareribs, barbecued	Prepare, cook, chill	Heat, serve
Pork, sweet-sour	Prepare, cook, chill	Heat, serve
Potato cakes, grilled	Prepare, chill	Cook, serve
Potato chips		Serve
Potatoes, au gratin	Prepare, cook, chill	Heat, serve
Potatoes, baked	Wash, bag	Bake, serve
Potatoes, cottage fried	Prepare potatoes	Cook, serve
Potatoes, franconia	Prepare, cook, chill	Heat, serve
Potatoes, french fried		Cook, serve
Potatoes, hash brown	Prepare potatoes	Cook, serve
Potatoes, home fried	Prepare, chill	Cook, serve
Potatoes, lyonnaise	Prepare, cook, chill	Heat, serve
Potatoes, mashed		Rehydrate, serve
Potatoes, O'Brien	Prepare, cook, chill	Heat, serve
Potatoes, oven browned	Prepare, chill	Cook, serve
Potatoes, parsley buttered	Prepare, chill	Cook, serve
Potatoes, rissole	Prepare, cook, chill	Heat, serve
Potatoes, scalloped	Prepare, cook, chill	Heat, serve
Potatoes, sweet candied	Prepare, cook, chill	Heat, serve
Puddings, cake	Prepare, bake	Serve
Radishes	Prepare	Serve
Rice, fried	Prepare, cook, chill	Heat, serve
Rice, steamed		Cook, serve
Rolls, cinnamon	Prepare, bake	Serve
Rolls, dinner	Prepare, bake	Serve
Rolls, frankfurter		Serve
Rolls, pecan	Prepare, bake	Serve
Salad, banana	Prepare dressing	Combine, serve
Salad, cabbage and sweet pepper	Prepare ingredients	Combine, serve
Salad, carrot	Prepare	Serve
Salad, carrot & pineapple	Prepare	Serve
Salad, chef	Prepare ingredients	Slice tomatoes, combine, serve
Salad, cottage cheese	Prepare lettuce	Combine, serve
Salad, cottage cheese & peach	Prepare lettuce	Combine, serve
Salad, fruit		Serve
Salad, garden vegetable	Prepare ingredients	Combine, serve
Salad, green, tossed	Prepare ingredients	Combine, serve
Salad, garden glow	Prepare, chill	Serve
Salad, jellied, banana	Prepare, chill	Serve
Salad, jellied, fruit	Prepare, chill	Serve
Salad, jellied, pear	Prepare, chill	Serve
Salad, jellied, spice, cherry	Prepare, chill	Serve
Salad, kidney bean	Prepare, chill	Serve
Salad, lettuce	Prepare lettuce	Serve
Salad, lettuce & tomato	Prepare ingredients except tomatoes	Slice tomatoes, combine, serve

Product	Central Preparation	Dining Hall
Salad, perfection	Prepare, chill	Serve
Salad, pineapple cheese	Slice cheese, prepare lettuce	Combine, serve
Salad, spring	Prepare ingredients	Combine, serve
Salad, potato	Prepare, chill	Serve
Salad, three bean	Prepare, chill	Serve
Salad, tuna	Prepare lettuce, celery	Prepare, combine, serve
Salad, turkey	Prepare lettuce, cook, dice, chill turkey	Combine, serve
Salad, waldorf	Prepare ingredients	Combine, serve
Salmon loaf	Prepare, cook, chill	Heat, serve
Sandwich, bacon & cheese	Slice cheese, prefry bacon	Heat bacon, combine, serve
Sandwich, bacon, lettuce, tomato	Prefry bacon, prepare lettuce	Slice tomatoes, heat bacon, assemble, serve
Sandwich, corned beef	Cook corned beef, chill	Slice, heat, assemble, serve
Sandwich, grilled cheese	Slice cheese	Prepare, cook, serve
Sandwich, grilled ham & cheese	Slice ham and cheese	Combine, heat, serve
Sandwich, hot meat ball	Prepare, cook, chill meatballs	Heat, combine, serve
Sandwich, hot pork	Prepare, slice pork, chill	Heat pork, prepare, serve
Sandwich, hot roast beef	Prepare beef, chill	Heat, combine, serve
Sandwich, hot turkey	Cook, slice turkey chill	Heat, combine, serve
Sandwich, submarine	Slice cheese, meats; prepare lettuce	Slice tomatoes, assemble, serve
Sandwich, western	Dice ham and lettuce	Prepare, serve
Sauce egg	Prepare, chill	Heat, serve
Sauerkraut	Prepare (with spareribs)	Heat, serve
Scallops, fried		Cook, serve
Seafood platter		Cook, serve
Sherbet		Serve
Shortcake	Prepare, bake	Whip topping, add fruit & topping, serve
Shrimp, french fried		Cook, serve
Soup	Prepare, cook, chill	Heat, serve
Spaghetti with meat balls	Prepare, cook, chill	Heat, serve
Spaghetti with meat sauce	Prepare, cook separately, chill	Heat, serve
Spinach		Prepare, cook, serve
Squash, creole	Prepare, cook, chill	Heat, serve
Swedish tea ring	Prepare, bake	Cut, serve
Tartar sauce		Serve
Tea, hot or iced		Prepare, serve
Toast		Prepare, serve
Toast, french	Prepare, grill, freeze	Heat, serve
Tomatoes, scalloped	Prepare, chill	Heat, serve
Tomatoes, stewed	Prepare, chill	Heat, serve

Product	Central Preparation	Dining Hall
Topping, ice cream	Prepare, chill	Serve
Torte, applesauce	Prepare, bake	Serve
Tuna & noodles, baked	Prepare, cook, chill	Heat, serve
Turkey pot pie	Prepare, cook, chill	Heat, serve
Turkey roast		Roast, slice, serve
Vealburgers	Prepare, form, freeze	Cook, serve
Veal loaf	Prepare, cook, chill	Heat, serve
Veal parmesan	Prepare, cook, chill	Heat, serve
Veal roast		Prepare, cook, serve
Veal steaks, braised		Cook, serve
Veal steaks, breaded	Prepare, cook, chill	Heat, serve
Vegetables, mixed		Cook, serve
Wafers, vanilla		Serve

1/ Preparation required at central preparation or dining hall will vary depending upon the type and state of raw material as received.

2/ Some changing of work between central preparation and dining hall will be dictated by local conditions.

TABLE 2

Bakery Product Panel Ratings (Flavor) During Storage on a 9-Point Scale 1/ (N = 10)

Product 2/	Storage Time - Days				
	Initial	1	2	6	7
Bread Pudding	7.9	7.2	7.1	5.7	5.8
Lemon Cake Pudding	6.4	6.8	6.9	6.4	6.4
Lemon Meringue Pie	6.8	7.0	7.2	6.9	5.7
Chocolate Cream Pie	7.3	7.3	7.7	6.9	7.2
Peach Crisp	7.6	6.1	7.2	4.9	4.7
Cherry Cake Pudding	7.2	6.8	6.8	5.5	5.3
Apple Pie	7.4	7.2	7.2	7.1	7.2
Banana Cake	7.7	7.6	7.5	6.7	6.8
Chocolate Cake	7.8	7.6	7.6	7.5	7.3

1/ Technological panels rated products for all organoleptic factors. However, flavor was a true indicator of quality deterioration showing as much or greater than any other factor.

2/ All products stored at 40°F. except chocolate cake which was stored at room temperature.

TABLE 3

Meat & Entree Panel Ratings During Storage on a 9-Point Scale 1/ (N = 10)

	Initial Acceptance Rating Consumer Panel 2/	Initial Flavor Rating Tech. Panel	Storage Time — Days 1		2		3		7		10	
			40°	0°	40°	0°	40°	0°	40°	0°	40°	0°
Beef, corned	6.9	7.0	6.7	6.7	6.5	6.7	6.6	6.5	6.3	6.4	6.4	6.0
Beef, Creamed, ground 3/	4.9	6.4	5.8	6.2	6.4	6.6	6.4	6.1	5.4	5.8	5.7	5.8
Beef cubes, barbecued	7.3	6.7	6.7	6.7	6.1	6.6	6.0	6.3	5.8	6.1	5.6	5.7
Beef, ground, barbecued	6.5	7.3	6.5	6.5	6.1	6.2	6.1	6.3	6.4	6.7	6.2	6.3
Beef, patties, baked, Spanish	8.0	7.6	6.7	7.0	7.1	7.2	7.2	6.8	6.9	6.6	6.9	6.8
Beef pot roast	7.8	7.5	7.3	7.0	7.0	6.6	6.4	6.7	5.5	6.6	3.9	6.2
Beef, roast	7.4	6.8	6.7	6.7	6.5	6.5	6.1	6.3	5.9	6.6	5.4	6.5
Beef, salisbury steak	7.5	6.8	6.9	7.0	4/	4/	6.6	6.7	6.9	7.0	4/	4/
Beef stew 5/	7.1	4.5	6.4	5.8	5.1	5.3	6.0	5.7	6.0	5.8	6.4	6.0
Beef, swiss steak	6.6	7.6	6.7	7.6	6.8	7.1	6.4	6.1	6.1	6.4	5.9	6.3
Chicken, country style	7.4	7.8	6.9	7.0	5.7	6.7	5.9	6.5	5.5	6.9	4.2	6.1
Chicken, oven fried	7.9	8.3	7.5	7.2	6.8	6.9	6.0	6.8	6.7	5.4	5.1	6.3
Chicken pot pie	7.6	7.6	6.7	6.9	7.1	6.1	6.6	6.8	6.8	7.0	5.2	6.4
Chili con carne	6.6	6.9	6.6	6.8	6.3	6.4	6.3	6.4	6.0	6.7	6.4	6.1
Chop suey, pork	7.4	7.0	7.0	6.8	6.7	6.6	6.3	6.5	6.3	6.1	6.8	6.9
Franki rters w/barbecue sauce	7.3	7.2	7.3	7.1	7.1	6.8	7.0	6.9	6.2	6.5	5.8	6.2
Ham, baked	7.0	7.1	6.8	6.5	6.3	6.2	5.7	6.2	5.9	6.7	5.6	6.4
Lasagna	6.7	6.8	6.8	6.6	6.8	6.2	6.1	6.6	6.3	6.2		
Macaroni & cheese, baked	7.6	7.2	7.1	7.3	6.0	5.5	6.4	7.0	6.6	6.1	5.9	6.6
Meat balls, Swedish	7.5	7.2	6.7	6.5	7.1	7.1	6.4	6.7	5.7	6.6	5.6	6.3
Meat loaf	6.3	6.6	6.0	6.5	6.7	6.8	6.6	6.5	5.2	6.1	4.6	6.0
Pork slices, breaded	7.7	7.1	6.4	6.9	5.1	6.9	5.0	6.4	4.9	6.2	4.5	5.9
Pork spare ribs	7.4	6.9	6.9	6.9	6.8	6.4	6.8	6.7	6.2	5.6	5.1	4.4
Salmon loaf	5.6	7.1	6.8	6.5	7.0	7.3	6.2	6.0	4.6	5.4	5.0	5.1
Spaghetti w/meat balls	7.7	7.1	7.0	7.4	6.6	7.0	6.7	6.6	6.1	6.3	6.3	6.5
Spaghetti w/meat sauce	7.1	6.1	6.5	6.1	6.1	6.1	5.9	6.4	5.3	6.2	5.7	6.1
Toast, french	7.8	7.4	7.1	7.1	6.3	7.2	7.1	6.9	6.9	6.9	7.1	7.2
Tuna & noodles	7.5	7.7	6.8	7.3	6.9	7.2	6.9	6.9	6.5	6.0	6.4	6.6
Veal patties	6.6	6.7	6.4	6.5	6.6	6.6	6.0	6.4	6/	6.0	6/	5.8
Veal roast	5.8	7.3	6.4	6.8	6.5	6.3	5.6	6.6	5.0	5.8	6/	6.2

1/ The technological ratings in Table 2 cannot be directly correlated with either consumer panel ratings or with expected acceptance at Ft. Lewis. They can be used only to show changes which occur and even in this area they will show changes that may not be representative of the normal consumer. Small changes (.1 to .5) are within experimental error and are not significant.

2/ N = 40.

3/ Appearance not rated good - corrected.

4/ Samples lost.

5/ Spicing incorrect - corrected.

6/ High microbiological counts.

TABLE 4

Sandwich Panel Ratings (Flavor) During Storage on a 9-Point Scale (N=10)

Sandwich	Type	Storage Time: Initial	40°F. 24 Hrs.	40°F. 48 Hrs.	4 days at 10°F. 24 Hrs. at 40°F.	7 days at 10°F. 48 Hrs. at 40°F.
Turkey	No spread	7.2	7.2	7.0	7.8	6.9
	Margarine	8.1	7.6	7.4	8.0	7.0
Chicken	No spread	7.1	7.2	7.0	7.6	6.6
	Margarine	8.3	7.4	7.4	8.0	6.9
Roast Beef 1/	No spread	6.4	6.5	6.0	6.6	6.6
	Margarine	8.0	6.9	6.4	7.6	6.7
	Mayonnaise	7.2	7.1	6.4	7.6	—
Ham	No spread	8.2	7.6	7.6	7.6	7.1
	Margarine	9.0	7.8	7.7	7.8	7.3
Ham & Cheese	No spread	9.0	7.4	7.4	7.6	7.3
	Margarine	9.2	7.4	7.4	8.0	7.2
Tuna Fish 2/	No spread	5.2	6.7	6.0	6.4	5.6
	Margarine	7.4	7.6	7.4	7.6	6.4
	Mayonnaise	8.2	7.8	7.7	5.0	—

1/ Panel considered roast beef to be of low quality. This was corrected later.

2/ Conversion to a tuna fish salad with mayonaise and pickle relish provides a superior sandwich.

TABLE 5

Soup Panel Ratings (Flavor) During Storage (40°F.) on a 9-Point Scale

(N = 10)

Product	Initial Consumer Acceptance Rating 1/	Storage Time - Days: Initial	1	5	8	13
Vegetable Soup (Beef Stock)	7.3	6.1	6.9	6.9	6.5	6.3
Vegetable Soup (Soup Base)	—	7.0	6.5	6.6	6.9	6.5
				2 Days	6 Days	9 Days
Bean Soup	7.3	7.3	6.9	7.0	6.8	6.5
					5 Days	7 Days
Clam Chowder (New England Style)	7.7	6.9	7.3	—	7.1	6.9
Cream of Potato	7.8	7.5	7.2	6.8	7.1	6.7
Minestrone Soup	7.2	7.5	7.6	—	7.4	7.1
Tomato Bouillon	7.1	6.3	6.4	6.5	5.7	6.0

1/ N = 40

TABLE 6

Pizza Panel Ratings (Flavor) on a 9-point Scale After 2 Days

(N=10)

Variety	Flavor Rating	
	Refrigerated	Frozen
Mushroom	6.9	7.0
Pepperoni	7.4	7.8
Sausage	7.2	7.3
Salami	6.3	6.4
Anchovy	5.6	6.8

TABLE 7

Potato Products Panel Ratings (Flavor) During Storage (40°F.) on a 9-Point Scale (N = 10)

Product	Initial Consumer Acceptance Rating 1/	Storage Time — Days						
		Initial	1	2	3	7	40°F.	0°F.
Oven Browned	7.1	7.2	6.8	6.8	6.8	5.6	6.1	5.1
O'Brien - Partial 2/	7.1	7.7	6.9	7.2	7.0	7.0	6.5	7.2
- Full 3/	7.1	7.7	5.3	5.4	5.1	4.7	4.0	5.2
French Fried - Partial	—	7.4	7.5	5.3	7.4	6.3	5.1	4.7
- Full	—	—	5.6	5.8	5.6	3.1	3.5	4.9
Lyonnaise	7.0	7.1	7.1	6.7	6.3	6.4	6.3	6.2
Rissole	7.5	7.4	6.8	6.2	—	6 days 5.8	9 days 5.8	5.9
Scalloped	7.5	7.3	6.7	6.6	—	6.8	6.5	6.7

1/ N = 40

2/ Partial - Blanch in frying oil initially - frying completed just prior to serving.

3/ Full - Completely fried initially - reheated in oven prior to serving.

TABLE 8

Microbiology of Chilled Prepared Meat Items During Refrigerated Storage

	Microorganisms Per Gram					
	Mesophiles			Psychrophiles		
	Days at 40 F			Days at 40 F		
Meat Item	0	6-7	9	0	6-7	9
Chicken Pot Pie	210	---	80	175	---	50
Pork Spareribs	65	35	35	20	30	45
BBQ Frankfurters	95	25	20	45	<10	<10
Corn Beef	20	16,000	60	20	7,300	25
BBQ Beef	25	<10	20	<10	<10	15
Roast Beef	725	1,100	15,000	625	900	13,000
Salisbury Steak	4,200	—	3,100	625	—	5,400
Fried Chicken	4,400	—	80	2,600	—	65
Pork Slices	40	—	—	10	—	—
Sliced Ham	1,500	135	75	1,400	120	30
Veal Roast Slices	1,625	350	175	900	425	155
Meat Balls with Spaghetti Sauce	15	50	25	10	40	10
Swedish Meat Balls	3,100	260	600	2,600	265	600
Baked Spanish Beef Patties	70	<10	15	15	<10	<10
Country Style Chicken	<100	15	15	<100	<10	<10
Raw Veal Burgers	—	2×10^8	—	—	1×10^8	—
Frozen Raw Veal Burgers	—	2×10^7	2×10^7	—	2×10^7	2×10^7
Breaded Veal Steaks	15	2,200	650	10	1,620	350

TABLE 9

Microbiology of Chilled Prepared Vegetable Items During Refrigerated Storage

Vegetable Items	Microorganisms Per Gram					
	Mesophiles			Psychrophiles		
	Days at 40 F			Days at 40 F		
	0	5-6	8-9	0	5-6	8-9
Rissoli Potatoes (Baked)	1,800	2,300	2,100	1,000	4,900	1,400
Rissoli Potatoes (Unbaked)	45,000	12,000	10,500	30,000	9,200	6,300
French Fried Potatoes (Baked)	420	140	100	400	85	25
French Fried Potatoes (Partially Baked)	1,200	2,000	140	1,000	200	45
Onion Rings (Baked)	1,300	145	15	900	140	50
Onion Rings (Partially Baked)	17,000	600,000	76,000	13,000	512,000	66,000
Oven Brown Potatoes (40 minute bake)	3,400	800	300	3,000	550	200
Oven Brown Potatoes (90 minute bake)	11,000	1,000	15	9,200	1,300	20
Lyonnaised Potatoes (Baked)	700	900	1,800	600	700	1,600
Lyonnaised Potatoes (Partially Baked)	18,000	16,000	4,300,000	19,000	14,000	4,300,000
O'Brien Potatoes (Baked)	345	1,400	11,000	2,100	1,200	8,000
O'Brien Potatoes (Unbaked)	25	—	—	15	—	—
Vegetables for O'Brien Potatoes (Unbaked)	30	—	—	15	—	—
Vegetables and O'Brien Potatoes Composited (Unbaked)	—	20	25	—	15	15

TABLE 9 (Cont)

Microbiology of Chilled Prepared Vegetable Items During Refrigerated Storage

	Microorganisms Per Gram					
	Mesophiles			Psychrophiles		
	Days at 40 F			Days at 40 F		
Vegetable Items	0	5-6	8-9	0	5-6	8-9
Stewed Tomatoes (Baked)	—	300	300*	—	200	200*
Stewed Tomatoes (Range Cooked)	—	200	400*	—	200	300*
Tomatoes and Onions (Partially Baked)	20	10	55	20	<10	25
Tomatoes and Onions (Baked)	15**	<10	25	15**	<10	25
Scalloped Potatoes (Baked)	85**	25	50	50**	35	35
Scalloped Potatoes (Unbaked)	—	2,100	200,000		1,200	307,000

* 10 days at 40 F

** 1 day at 40 F

TABLE 10

Microbiology of Soups, Salads and Miscellaneous Chilled Prepared Foods During Refrigerated Storage

	Microorganisms Per Gram					
	Mesophiles			Psychrophiles		
	Days at 40 F			Days at 40 F		
Food Items	0-1	4-6	7-9	0-1	4-6	7-9
Minestrone Soup (Concentrated 1:1)	15	<10	—	10	<10	—
Tomato Boullion Soup (Concentrated 1:1)	300	415	250	300	300	200
Vegetable Soup	65	<10	10	20	<10	<10
Vegetable Soup	15	10	10	15	<10	<10
Bean Soup (Concentrated 1:1)	15	40	95	20	50	100
Creme of Potato Soup (Concentrated 1:1)	200	320	180,000	135	115	160,000
Clam Chowder	335	470	480	525	170	320
Cucumber Salad without Vinegar	—	1,200,000*	35,000,000	—	420,000*	31,000,000
Cucumber Salad w/Vinegar	—	14,000	2,550	—	13,000*	1,300
Carrot Salad	440,000	350,000	3,600,000	410,000	360,000	2,700,000
Waldorf Salad	310,000	<10,000	7,800	300,000	< 10,000	7,300
Macaroni & Cheese	1,000	400	800	800	600	800
Salmon Loaf	1,400	800	7,200	1,600	600	5,400
Spaghetti w/o sauce	10	—	—	< 10	—	—
Gravy (For Country Style Chicken)	100	55	11,000	< 100	45	8,800
French Toast	25	700	125	30	500	115

* 3 days at 40 F

TABLE 11

Microbiology of Chilled Pastries During Refrigerated Storage

	Microorganisms Per Gram					
	Mesophiles			Psychrophiles		
	Days at 40 F			Days at 40 F		
Pastries	0	2	6	0	2	6
Lemon Cake Pudding	430	35	25	160	25	15
Bread Pudding	220	215	175	180	115	135
Lemon Meringue Pie	100	55	25	70	15	35
Chocolate Pie	23,450*	400	230	23,550 *	175	235
Peach Crisp	45	555	25	50	420	25
Apple Pie	35	15	45	35	< 10	< 10
Cherry Cake Pudding	25	25	25	< 10	20	30
Banana Cake	65	210	70	75	110	85

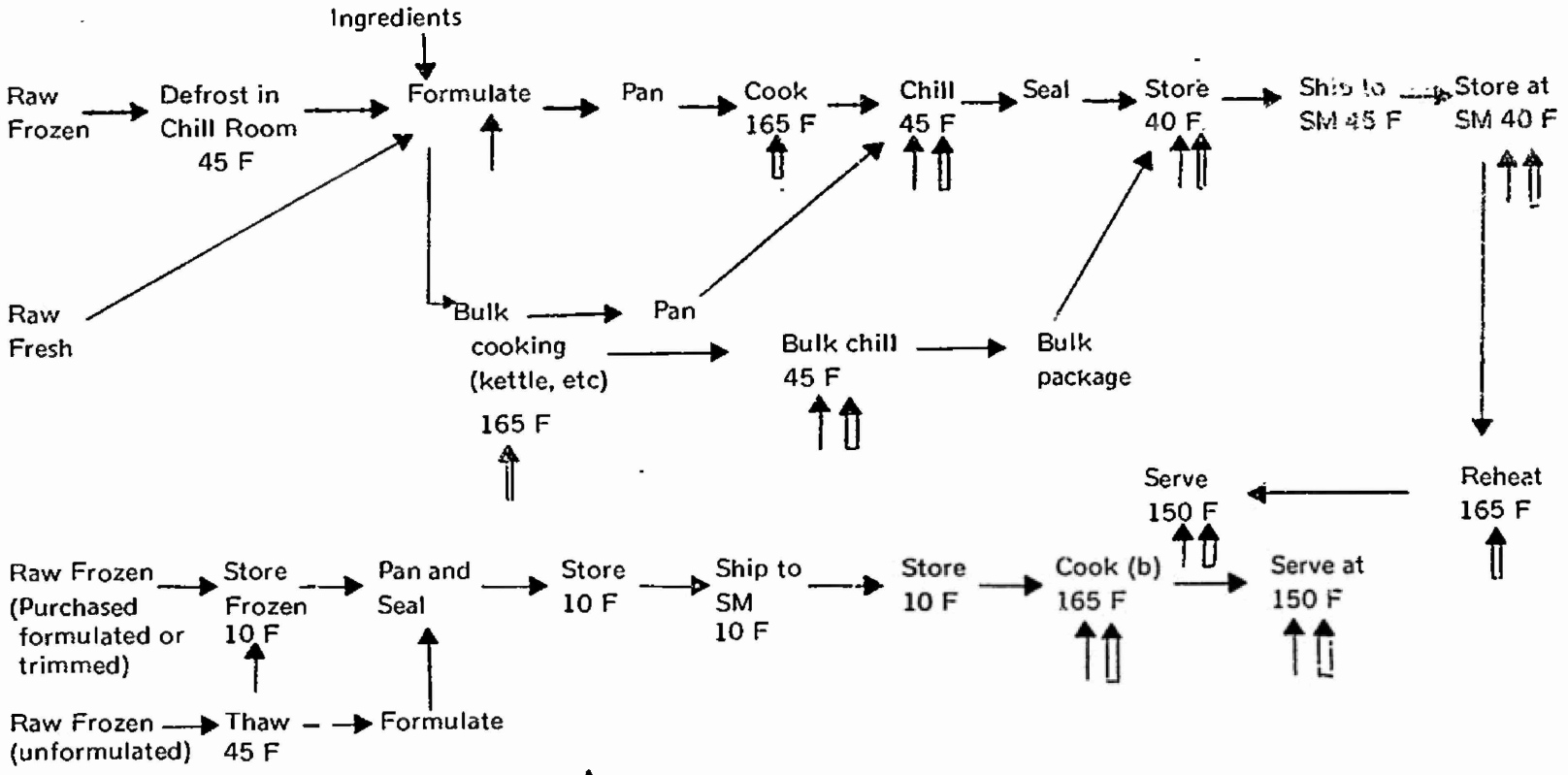
* Count was due to addition of whip cream which was added to pie.

TABLE 12

Microbiology of Frozen Sandwiches Stored for 7 Days at -10°F.

Sandwich	Mayonaisse	Margarine	Aerobic Plate Count	Coliforms	E.coli	Coagulase Positive Staphylococci
				Microorganisms Per Gram		
Turkey Roll	No	No	3000	< 100	< 100	< 10
Chicken Roll	No	No	< 1000	< 100	< 100	< 10
Chicken Roll	No	Yes	3500	< 100	< 100	< 10
Roast Beef	No	No	< 1000	< 100	< 100	< 10
Roast Beef	No	Yes	5500	< 100	< 100	< 10
Roast Beef	No	Yes	< 1000	< 100	< 100	> 10
Ham	No	No	1500	< 100	< 100	< 10
Ham	No	Yes	98,500	1000	< 100	< 10
Ham and Cheese	No	No	< 1000	< 100	< 100	< 10
Ham and Cheese	No	Yes	50,000	350	< 100	< 10
Tuna Fish	No	No	< 1000	< 100	< 100	< 10
Tuna Fish	No	Yes	< 1000	< 100	< 100	< 10

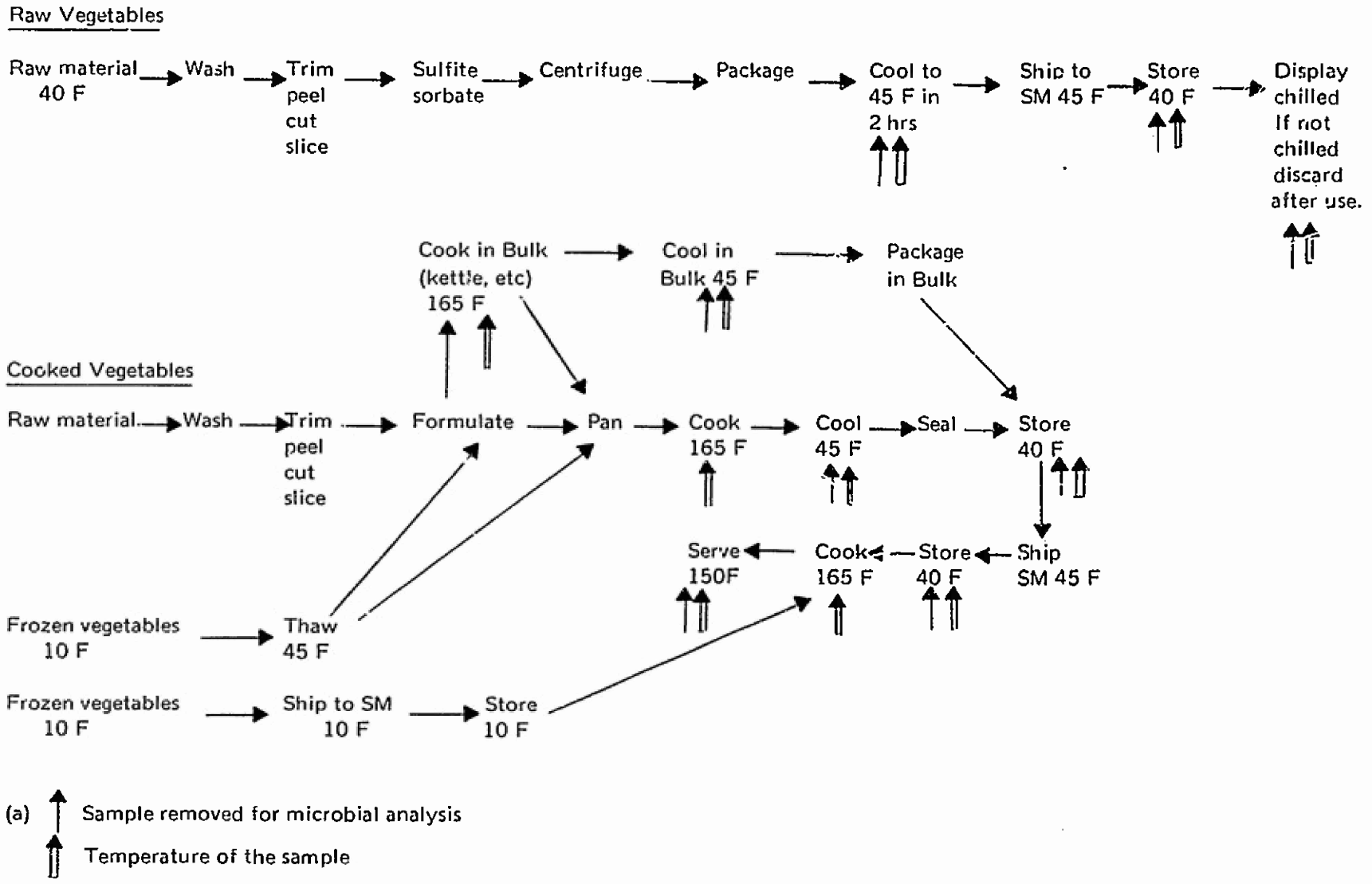
Figure 1. Flow chart for meat and meat formulations soups and gravies showing processing steps, the allowable temperature constraints and the stages (a) at which temperatures are monitored and the item sampled for microbial analyses.



(a) ↑ Sample removed for microbial analysis; ⇑ Temperature of the sample.

(b) Boned and rolled beef can be cooked to 150 F rather than 165 F. Oven temperatures can be higher and refrigeration temperatures lower than those specified in Figures 1 and 2.

Figure 2. Flow chart for cooked and frozen vegetables showing processing steps, the allowable temperature constraints and the stages (a) at which temperatures are monitored and the item sampled for microbial analysis.



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13. ABSTRACT

This report details the findings of food technology studies directed toward establishment of central food preparation at Ft. Lewis, Washington.

It is concluded that central food preparation has excellent possibilities for improving the feeding system. A basically chill system is recommended for the Ft. Lewis test with the recognition that there are logistic problems to be solved if it is extended to a larger operation. It is shown that changes are necessary in the Armed Service menus and recipes to adapt them to large scale preparation.

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